

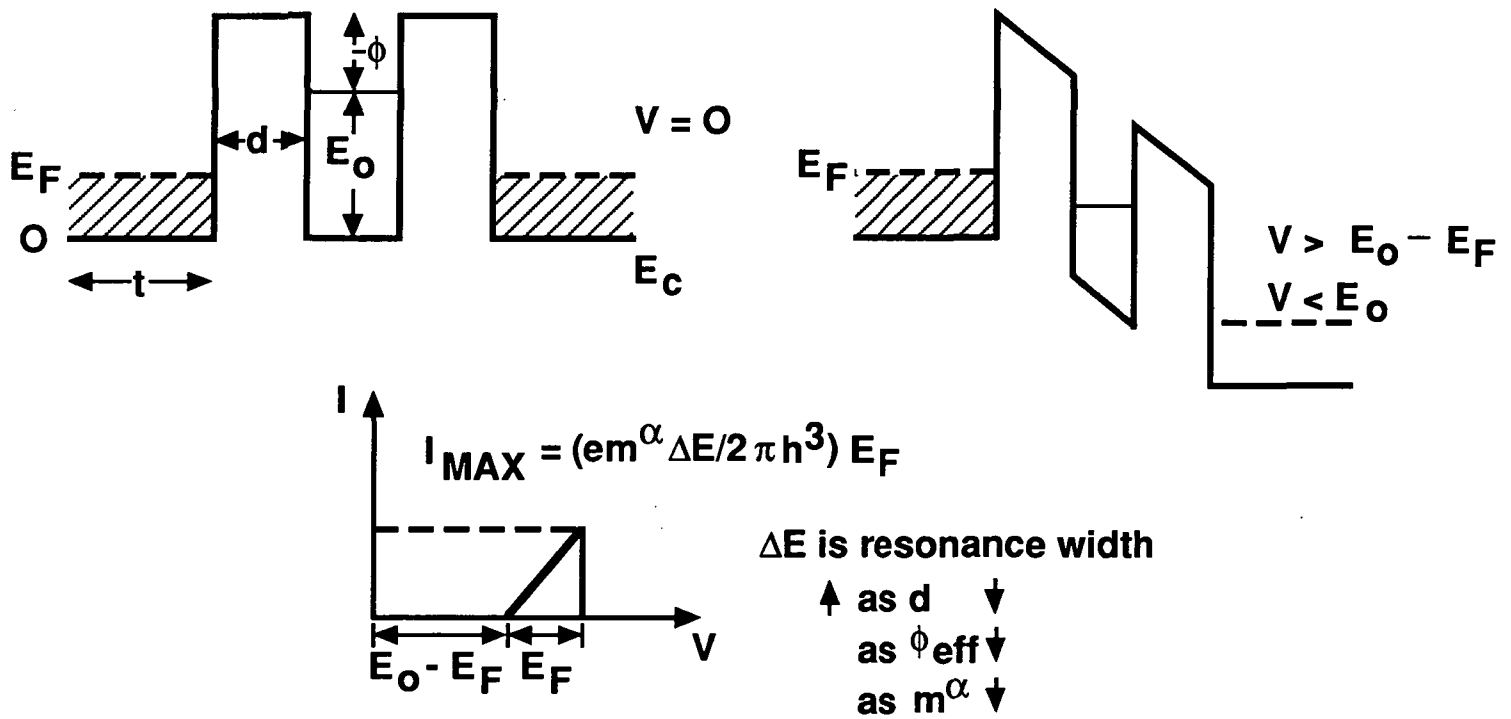
Resonant Tunneling IR Detectors

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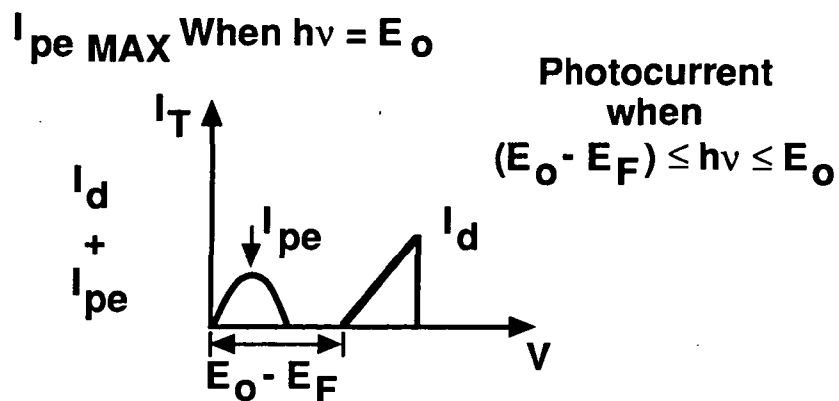
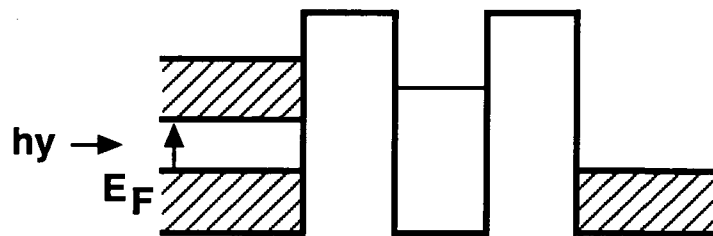
We propose a novel semiconductor heterojunction photodetector which would have a very low dark current and would be voltage tunable. A schematic diagram of the device and its band structure are shown in Figure 1. The two crucial components of the device are a cathode (InGaAs) whose conduction band edge is below the conduction band edge of the quantum wells and a resonant tunneling filter (GaAs-AlGaAs). In a standard resonant tunneling device the electrodes are made of the same material as the quantum wells, and this device becomes highly conducting when the quantum levels in the wells are aligned with the Fermi level in the negatively biased electrode. In contrast, our device is essentially non-conducting under the same bias conditions. This is because the Fermi Level of the cathode (InGaAs) is still well below the quantum levels so that no resonant transport occurs and the barriers (AlGaAs) effectively block current flow through the device. However, if light with the same photon energy as the conduction-band discontinuity between the cathode and the quantum wells, $E_{c3} - E_{c1}$ is shone on the sample, free carriers will be excited to an energy corresponding to the lowest quantum level in the well closest to the cathode ($h\nu + E_{c1} = E_0$). These electrons will resonantly tunnel through the quantum wells and be collected as a photocurrent in the anode (GaAs). To improve the quantum efficiency, the cathode (InGaAs) should be very heavily doped and capped with a highly reflective metal ohmic contact. The thickness of the device should be tailored to optimize thin film interference effects and afford the maximum absorption of light.

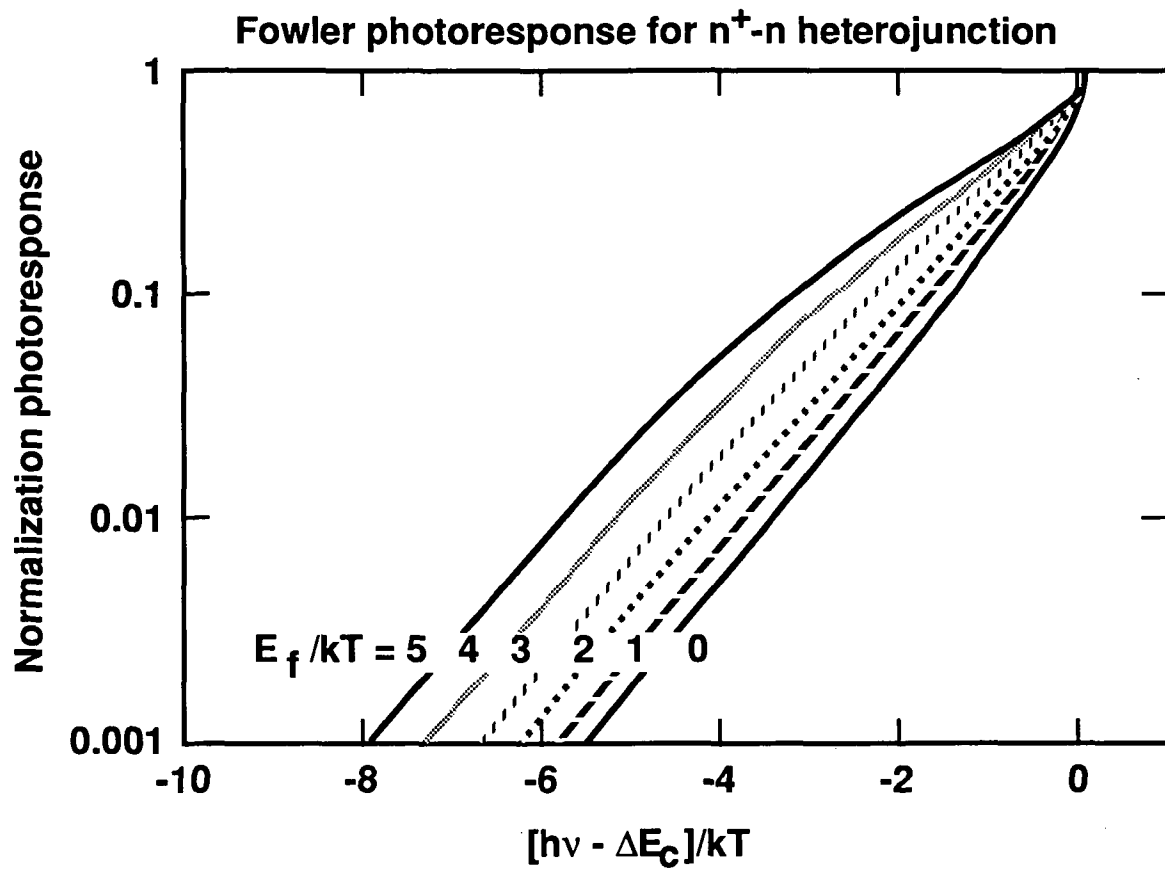
Because the device relies on resonant tunneling, its response should be very fast, and the small voltages needed to change the responsivity should allow for very high frequency modulation of the photocurrent. In addition, the device is tuned to a specific photon energy so that it can be designed to detect a fairly narrow range of wavelengths. This selectivity is important for reducing the photocurrent due to spurious light sources. Although we have cited the use of InGaAs, GaAs, and AlGaAs by way of example this device can be fabricated from a number of materials depending on the detector characteristics one desires. Also, the resonant tunneling filter may comprise any number of quantum wells to obtain the appropriate operating voltage so long as the filter region is not so thick that it significantly reduces the photocurrent when the electron energy is resonant with the levels in the wells.

RESONANT TUNNELING

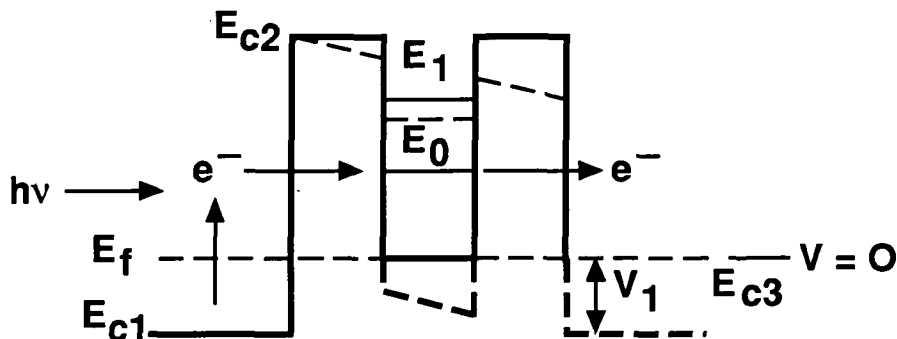


PHOTOEXCITED RESONANT TUNNELING



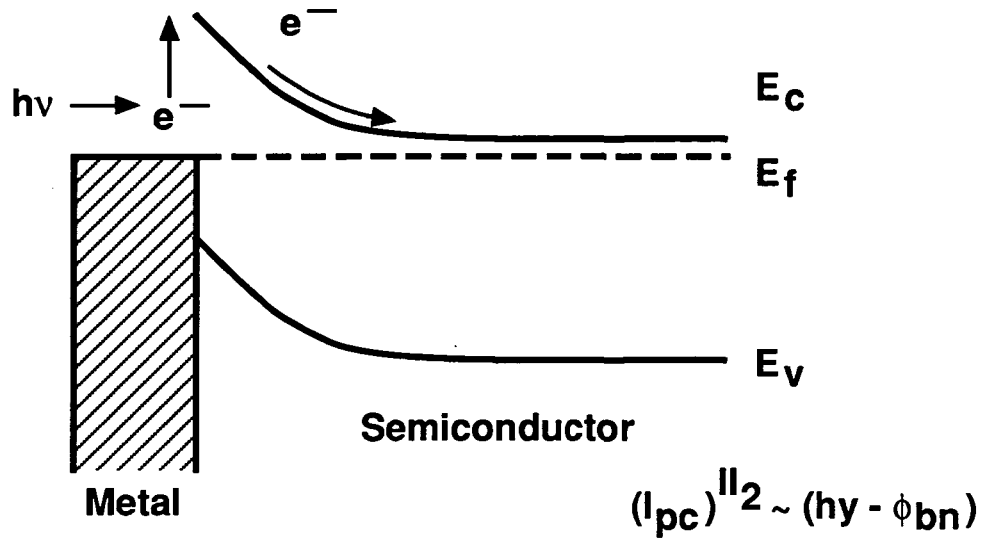


RESONANT TUNNELING IR-PHOTODETECTOR



- High IR absorption
- Low dark current

SCHOTTKY BARRIER INTERNAL PHOTOEMISSION DEVICE



- IR Photon excites e^- over barrier
- High dark current – barrier $\sim h\nu$
- Low quantum efficiency
- $\phi_{bn} = 0.8 \rightarrow -0.2$ for GaInAs

